Amendments to the Claims

This listing of claims will replace all prior versions, and listings, of claims in the application:

Listing of Claims:

Claim 1 (Canceled)

Claim 2 (Currently Amended): ~~The~~ A plane diffraction grating ~~according to claim 1~~ with grooves formed on a surface thereof, the plane diffraction grating being rotated about a rotational axis which is normal to the surface, and being characterized in that a profile of the grooves at a radial area is determined depending on an azimuthal position ϕ of the area about a rotational center defined as a foot of the rotational axis on the surface of the plane diffraction grating for maximizing a diffraction efficiency of the radial area,

wherein the plane diffraction grating is a blazed type, and a blaze angle θ_0 of the grooves in an area along an original line at the azimuthal angle $\phi = 0$ which is perpendicular to the grooves is set as:

$$\theta_0 = \frac{\alpha + \beta}{2},$$

where α is an angle of an incident ray from a normal to the surface of the plane diffraction grating in the area, and β is an angle of a diffraction ray from the normal, and

a blaze angle θ_φ of the grooves in an area along a line at the azimuthal position is set as

$$\sin\theta_\phi = \sin\theta_0 \sqrt{\frac{1+\tan^2\phi}{1+\tan^2\phi \sin^2\theta_0}}.$$

Claim 3 (Previously Presented): The plane diffraction grating according to claim 2, wherein:

the surface of the plane diffraction grating is covered with a multiple-layer coating to improve reflectivity;

a unit thickness db_{Φ} of the multiple-layer coating in the area along the original line at the azimuthal angle $\phi = 0$ satisfies the equation:

$$m_b \lambda = 2 d_{b\phi} R_{\alpha\phi} \cos(\alpha - \theta_0)$$

where

mb is the diffraction order,

$\lambda$is the wavelength of the light diffracted by the area,

$$R_{\alpha\phi} = \sqrt{1 - (2\delta_\phi - \delta^2{}_\phi)/\cos^2\alpha}\ ,$$

$\delta_\phi = 1 - n_\phi$,

n_ϕ is the average refractive index of the multiple-layer coating

and an unit thickness $d_{b\varphi}$ of the multiple-layer coating in the area along the line at the rotational position φ satisfies the equation:

$$m_b \lambda = 2 d_{b\phi} R_{\alpha\phi} \cos(\alpha - \theta_0)\,,$$

where

λ is the wavelength of the light diffracted by the area

$$R_{\alpha\phi} = \sqrt{1 - (2\delta_\phi - \delta^2{}_\phi)/\cos^2\alpha}\ ,$$

δ_φ=1- n_φ

$n_\varphi$is the average refractive index of the multiple-layer coating.

Claim 4 (Currently Amended): ~~The~~ A plane diffraction grating ~~according to claim 1~~ with grooves formed on a surface thereof, the plane diffraction grating being rotated about a rotational axis which is normal to the surface, and being characterized in that a profile of the grooves at a radial area is determined depending on an azimuthal position ϕ of the area about a rotational center defined as a foot of the rotational axis on the surface of the plane diffraction grating for maximizing a diffraction efficiency of the radial area,

wherein the plane diffraction grating is a laminar type, and a depth h_ϕ of the grooves in an area along a line at the azimuthal angle ϕ is set as

$$h_{\phi} = \frac{\lambda}{2(\cos\alpha + \cos\beta)},$$

where λ is the wavelength of the light diffracted by the area, α is an angle of an incident ray from a normal to the surface of the plane diffraction grating in the area, and β is an angle of a diffraction ray from the normal.

Claim 5 (Previously Presented): The plane diffraction grating according to claim 4, wherein:

the surface of the plane diffraction grating is covered with a multiple-layer coating to improve reflectivity;

a unit thickness db_ϕ of the multiple-layer coating in the area along the line at the azimuthal angle ϕ satisfies the equation:

$$m_b\lambda = d_{b\phi}(R_{\alpha\phi}\sin\alpha + R_{\beta\phi}\sin\beta),$$

where

mb is the diffraction order,

$$R_{\alpha\phi} = \sqrt{1-(2\delta_\phi - \delta_\phi{}^2)/\cos^2\alpha}\,,\ R_{\beta\phi} = \sqrt{1-(2\delta_\phi - \delta_\phi{}^2)/\cos^2\beta}\,,$$

$\delta = 1 - n_\Phi$,

n_Φ is the average refractive index of the multiple-layer coating,

and

an unit thickness $db\phi$ of the multiple-layer coating in the area along the line at the rotational position φ satisfies the equation:

$$m_b\lambda = d_{b\phi}(R_{\alpha\phi}\sin\alpha + R_{\beta\phi}\sin\beta),$$

where

λ is the wavelength of the light diffracted by the area

$$R_{\alpha\phi} = \sqrt{1-(2\delta_\phi - \delta^2{}_\phi)/\cos^2\alpha}\,,\ R_{\beta\phi} = \sqrt{1-(2\delta_\phi - \delta_\phi^2)/\cos^2\beta}\,,$$

$\delta_\varphi = 1\ n\varphi$,

n_φ is the average refractive index of the multiple-layer coating].

Claim 6 (Canceled)

Claim 7 (Currently Amended): ~~The~~ An optical system ~~according to claim 6~~, comprising:

a plane diffraction grating having grooves on a surface of the plane diffraction grating whose profile at an area is determined depending on an azimuthal position ϕ of the area about a rotational center defined as a foot of a rotational axis which is normal to the surface for maximizing a diffraction efficiency at the area;

a mechanism for rotating the plane diffraction grating about the rotational axis;

an incidence optical system for casting a converging beam of light on a point of the surface of the plane diffraction grating, the point being apart from the rotational center,

wherein the plane diffraction grating is a blazed type, and a blaze angle $\theta 0$ of the grooves in an area along an original line at the azimuthal angle ϕ=0 which is perpendicular to the grooves is set as:

$$\theta_0 = \frac{\alpha + \beta}{2},$$

where α is an angle of an incident ray from a normal to the surface of the plane diffraction grating in the area, and β is an angle of a diffraction ray from the normal, and

a blaze angle $\theta\varphi$ of the grooves in an area along a line at the azimuthal position ϕ is set as:

$$\sin\theta_\phi = \sin\theta_0 \sqrt{\frac{1+\tan^2\phi}{1+\tan^2\phi\sin^2\theta_0}}.$$

Claim 8 (Previously Presented): The optical system according to claim 7, wherein:

the surface of the plane diffraction grating is covered with a multiple-layer coating to improve reflectivity;

a unit thickness db_{ϕ} of the multiple-layer coating in the area along the original line at the azimuthal angle $\phi = 0$ satisfies the equation:

$$m_b \lambda = 2d_{b\phi} R_{\alpha\phi} \cos(\alpha - \theta_0),$$

where

mb is the diffraction order,

λ is the wavelength of the light diffracted by the area,

$$R_{\alpha\phi} = \sqrt{1 - (2\delta_\phi - \delta_\phi^2) / \cos^2 \alpha},$$

δ_ϕ = 1-n_ϕ,

n_ϕ is the average refractive index of the multiple-layer coating.

Claim 9 (Currently Amended): ~~The~~ <u>An</u> optical system ~~according to claim 6~~, <u>comprising:</u>

<u>a plane diffraction grating having grooves on a surface of the plane diffraction grating whose profile at an area is determined depending on an azimuthal position ϕ of the area about a rotational center defined as a foot of a rotational axis which is normal to the surface for maximizing a diffraction efficiency at the area;</u>

<u>a mechanism for rotating the plane diffraction grating about the rotational axis;</u>

<u>an incidence optical system for casting a converging beam of light on a point of the surface of the plane diffraction grating, the point being apart from the rotational center,</u>

wherein the plane diffraction grating is a laminar type, and a depth $h0$ of the grooves in an area along an original line at the azimuthal angle ϕ is set as

$$h_\phi = \frac{\lambda}{2(\cos\alpha + \cos\beta)},$$

where λ is the wavelength of the light diffracted by the area, α is an angle of an incident ray from a normal to the surface of the plane diffraction grating in the area, and β is an angle of a diffraction ray from the normal.

Claim 10 (Previously Presented): The optical system according to claim 9, wherein:

the surface of the plane diffraction grating is covered with a multiple-layer coating to improve reflectivity;

a unit thickness db_ϕ of the multiple-layer coating in the area along the line at the azimuthal angle ϕ satisfies the equation:

$$m_b\lambda = d_{b\phi}(R_{\alpha\phi}\sin\alpha + R_{\beta\phi}\sin\beta),$$

where

mb is the diffraction order,

$$R_\phi = \sqrt{1-(2\delta_\phi - \delta_\phi{}^2)/\cos^2\alpha}\,,\quad R_{\beta\phi} = \sqrt{1-(2\delta_\phi - \delta_\phi{}^2)/\cos^2\beta}\,,$$

$\delta = 1\ n_\phi$,

n_ϕ is the average refractive index of the multiple-layer coating

Claim 11 (Cancelled)

Claim 12 (Currently Amended): ~~The plane diffraction grating~~ A method of producing ~~method according to claim 11,~~ a plane diffraction grating having grooves on a surface thereof whose profile at an area is determined depending on an azimuthal position ϕ of the area about a rotational center defined as a foot of a rotational axis for maximizing a diffraction efficiency of the area, the method comprising the steps of:

coating a substrate with a photo-resist layer and forming a photo-resist mask from the photo-resist layer according to a preset pattern of groove arrangement;

covering the photo-resist mask with a sector mask having an opening of a narrow sector whose apex is set at the rotational center;

etching the substrate over the sector mask with an appropriate etching condition depending on a rotational position of the sector mask about the rotational center;

rotating the sector mask by an angle of the apex of the narrow sector; and

repeating the etching process and the mask rotating process until the narrow sector sweeps the surface of the substrate,

wherein the plane diffraction grating is a blazed type, and the etching condition in the etching process is such that:

a blaze angle $\theta 0$ of the grooves in an area along an original line at the azimuthal angle ϕ = 0 which is perpendicular to the grooves is set as

$$\theta_0 = \frac{\alpha + \beta}{2},$$

where α is an angle of an incident ray from a normal to the surface of the plane diffraction grating in the area, and β is an angle of a diffraction ray from the normal, and

a blaze angle $\theta\phi$ of the grooves in an area along a line at the azimuthal position ϕ is set as

$$\sin\theta_\phi = \sin\theta_0\sqrt{\frac{1+\tan^2\phi}{1+\tan^2\phi\sin^2\theta_0}}.$$

Claim 13 (Previously Presented): The plane diffraction grating producing method according to claim 12, wherein the surface of the plane diffraction grating is then covered with a multiple-layer coating to improve reflectivity, and:

a unit thickness db_ϕ of the multiple-layer coating in the area along the original line at the azimuthal angle $\phi = 0$ satisfies the equation:

$$m_b\lambda = 2d_{b\phi}R_{\alpha\phi}\cos(\alpha-\theta_0),$$

where

mb is the diffraction order,

λ is the wavelength of the light diffracted by the area,

$$R_{\alpha\phi} = \sqrt{1-(2\delta\phi-\delta\phi^2)/\cos^2\alpha},$$

$\delta_\phi = 1 - n_\phi$,

n_ϕ is the average refractive index of the multiple-layer coating

Claim 14 (Currently Amended): ~~The plane diffraction grating~~ A method of producing ~~method according to claim 11,~~ a plane diffraction grating having grooves on a surface thereof whose profile at an area is determined depending on an azimuthal position ϕ of the area about a rotational center defined as a foot of a rotational axis for maximizing a diffraction efficiency of the area, the method comprising the steps of:

coating a substrate with a photo-resist layer and forming a photo-resist mask from the photo-resist layer according to a preset pattern of groove arrangement;

covering the photo-resist mask with a sector mask having an opening of a narrow sector whose apex is set at the rotational center;

etching the substrate over the sector mask with an appropriate etching condition depending on a rotational position of the sector mask about the rotational center;

rotating the sector mask by an angle of the apex of the narrow sector; and
repeating the etching process and the mask rotating process until the narrow sector sweeps the surface of the substrate,

wherein the plane diffraction grating is a laminar type, and the etching condition in the etching process is such that:

a depth h_ϕ of the grooves in an area along a line at the azimuthal angle ϕ is set as

$$h_\phi = \frac{\lambda_{[0]}}{2(\cos\alpha + \cos\beta)},$$

where λ is the wavelength of the light diffracted by the area, α is an angle of an incident ray from a normal to the surface of the plane diffraction grating in the area, and β is an angle of a diffraction ray from the normal,

Claim 15 (Previously Presented): The plane diffraction grating producing method according to claim 14, wherein the surface of the plane diffraction grating is then covered with a multiple-layer coating to improve reflectivity, and:

a unit thickness db_ϕ of the multiple-layer coating in the area along the line at the azimuthal angle ϕ satisfies the equation

$$m_b \lambda_\phi = d_{b\phi}(R_{\alpha\phi} \sin\alpha + R_{\beta\phi} \sin\beta),$$

where

mb is the diffraction order,

$$R_{\alpha\phi} = \sqrt{1-(2\delta_\phi - \delta_\phi{}^2)/\cos^2\alpha}\,,\quad R_{\beta\phi} = \sqrt{1-(2\delta_\phi - \delta_\phi{}^2)/\cos^2\beta}\,,$$

$\delta = 1 - n_\phi$,

where n_ϕ is the average refractive index of the multiple-layer coating.